

1 I CLAIM:

2 1. A method of heating a subterranean formation  
3 comprising:

4 (a) forming a hole into said formation;

5 (b) inserting into said hole a heater comprising a  
6 casing and plural fuel cells contained within  
7 said casing;

8 (c) operating said fuel cells so as to produce heat  
9 and electricity; and

10 (d) wherein the said formation, when heated,  
11 generates a gaseous product, and wherein said  
12 gaseous product is provided to and used by said  
13 fuel cells as fuel.

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15 2. The heating method of claim 1, wherein, at least  
16 after an initial start-up period, said fuel cells are fueled  
17 by about 10% or more of the gaseous product generated by the  
18 formation.

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20 3. The heating method of claim 1, wherein said casing  
21 has an outside diameter, and said hole has an inside  
22 diameter at least somewhat greater than said casing outside  
23 diameter, thereby defining therebetween a substantially  
24 annular gap, and said method further comprises the step of  
25 filing said gap with a thermally conductive substance.

1        4.    The heating method of claim 1, wherein said  
2    formation is to be heated at a specified rate per heater  
3    segment, and wherein said heater segment is adapted to  
4    produce a thermal output substantially equal to that  
5    specified for the formation.

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7        5.    The heating method of claim 4, wherein said heater  
8    segment would have greater than desired combined thermal  
9    output if said fuel cells were configured continuously  
10   within said segment, and said adaptation is achieved by  
11   interleaving spacers within said fuel cells.

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13       6.    The heating method of claim 4, wherein each of said  
14   fuel cells has a thickness and an active component surface  
15   area, and wherein said adaptation is achieved by reducing  
16   said surface area in proportion to said thickness whereby  
17   said fuel cells when arranged continuously produce a  
18   combined thermal output substantially equal to that  
19   specified.

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21       7.    The heating method of claim 1 further comprising  
22   inserting additional electricity powered heaters into the  
23   formation and using the electrical output of at least some  
24   of said fuel cells to power said electrically powered  
25   heaters.

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2       8.    The heating method of claim 1, wherein said fuel  
3   cells generate a relatively warm exhaust gas, and wherein  
4   said method further comprises collecting said exhaust gas  
5   and using it to heat the formation.

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7       9.    A method of heating a subterranean formation  
8   comprising:

9           (b)   (a) forming a hole into said formation; inserting  
10                into said hole a heater comprising a casing and  
11                plural fuel cells contained within said casing;

12           (c)   operating said fuel cells so as to produce heat  
13                and electricity; and

14           (d)   continuously supplying said fuel cells with an  
15                oxidant and fuel via a continuous conduit to a  
16                planetary surface.

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18       10.   A subterranean formation heater comprising:

19           a casing having a plurality of fuel cells;

20           wherein the fuel cells have a feedback connection to  
21                the subterranean formation for receiving a fuel  
22                from the subterranean formation; and

23           wherein at least a portion of a total fuel used to  
24                power the fuel cells is supplied via the  
25                feedback connection.

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11. A subterranean formation heater comprising:
- a casing having a plurality of fuel cells;
  - an oxidant conduit and a fuel conduit connected directly to or near a planetary surface; and
  - wherein the fuel cells run in a continuous and/or intermittent process mode as fed by a continuous and/or intermittent supply of the oxidant and the fuel passing through said conduits.
12. A conduction heater comprising:
- a plurality of fuel cells;
  - a plurality of conduits, each conduit being in gaseous communication with at least one of said fuel cells;
  - a manifold comprising conduits but no fuel cells; and
  - wherein the manifold connects a planetary surface to the plurality of fuel cells.
13. The heater of claim 12, wherein at least one of said manifold conduits conducts relatively warmer gas away from said fuel cells and at least one of said conduits conducts relatively cooler gas towards said fuel cells, and wherein said manifold is adapted to transfer heat from said warmer gas to said cooler gas.

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2       14. The heater of claim 12, wherein said manifold  
3 comprises thermal insulation to inhibit transfer of heat  
4 from said manifold to a surrounding environment.

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6       15. A conduction heater for heating a subterranean  
7 formation, said conduction heater comprising:

8           a plurality of fuel cells;

9           a plurality of conduits, each conduit being in  
10           gaseous communication with at least one of said  
11           fuel cells;

12          a casing enclosing said fuel cells;

13          each of said fuel cells comprises an anode and a  
14          cathode separated by an electrolyte;

15          at least some of said fuel cells are electrically  
16          coupled in a series;

17          wherein each of said fuel cells comprises at least

18           one plate having plural holes formed therein, at  
19           least one of said holes in gaseous communication  
20           with said fuel cell;

21          wherein said conduits are formed by aligning

22           corresponding of said holes in each of said fuel  
23           cells to form a continuous passageway;

24          wherein said plates are assembled into a stack  
25          module; and

1            wherein the stack modules are interconnectable in a  
2            linearly scalable manner, thereby providing a  
3            desired length for the conduction heater.  
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5        16. A conductive heater comprising:  
6            a fuel cell ceramic mounted in a plate;  
7            a vertical assembly of plates forming a stack which  
8            is mounted in a casing;  
9            each casing having an end connector, thereby forming  
10           a geothermic fuel cell module; and  
11           wherein a plurality of geothermic fuel cell modules  
12           are assembled end to end to form a conductive  
13           heater of a desired length.  
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15        17. The conductive heater of claim 16, wherein each  
16        plate has a plurality of holes, thereby forming a plurality  
17        of conduits within the casing, at least one of the conduits  
18        forming an exhaust conduit, wherein exhaust gases are  
19        conveyed in a gaseous state to a planetary surface.  
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21        18. A conductive heater comprising:  
22            a fuel cell ceramic mounted in a plate;  
23            a vertical assembly of plates forming a stack which  
24            is mounted in a casing;

1            wherein each plate has a plurality of holes, thereby  
2            forming a plurality of conduits within the  
3            casing;  
4            at least one of the conduits forming an exhaust  
5            conduit; and  
6            wherein exhaust gases are conveyed in a gaseous state  
7            to a planetary surface.

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9        19. A conductive heater comprising:  
10        a fuel cell ceramic mounted in plate;  
11        a vertical assembly of plates forming a stack which  
12        is mounted in a casing;  
13        wherein a stack is assembled to form a conductive  
14        heater of a desired length; and  
15        wherein said stack has a plurality of conduits  
16        connected to a planetary surface for feeding  
17        fuel to the fuel cells.

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19        20. The conductive heater of claim 19, wherein each  
20        plate has a plurality of holes, thereby forming a plurality  
21        of conduits within the casing, at least one of the conduits  
22        forming an exhaust conduit, wherein exhaust gases are  
23        conveyed in a gaseous state to a planetary surface.

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25        21. A conductive heater comprising:

1           a plurality of conduits in a borehole;  
2           said plurality of conduits communicating from a  
3           planetary surface to a plurality of fuel cells  
4           in the borehole;  
5           wherein the conduits provide a passageway for at  
6           least an oxidant and a fuel for the fuel cells;  
7           and  
8           wherein a quantity of the plurality of fuel cells is  
9           selected to provide a desired heat output.  
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11          22. The conductive heater of claim 21 further  
12 comprising a segment of the plurality of conduits which  
13 forms a manifold not comprising a fuel cell.  
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15          23. The conductive heater of claim 22, wherein the  
16 manifold further comprises a heat exchanger.  
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18          24. A method to start up a down hole conduction heater,  
19 comprising the steps of:  
20           forming a stack of fuel cells in a casing;  
21           inserting the stack down a borehole;  
22           feeding the stack with a plurality of conduits to  
23           supply an oxidant and fuel to the stack; and

1 bringing a temperature of the stack up to an  
2 operating temperature in the range of about 750°C  
3 to about 1000°C.  
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5 25. The method of claim 24 further comprising the step  
6 of circulating a preheated fluid through at least one  
7 conduit for bringing the temperature of the stack up.  
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9 26. The method of claim 24 further comprising the step  
10 of using a voltage applied to the stack for bringing the  
11 temperature of the stack up.  
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13 27. A conductive heater for heating an underground  
14 resource layer to facilitate mining the underground resource  
15 layer, the conductive heater comprising:

16 a plurality of conduits connecting a planetary  
17 surface to a plurality of fuel cell assemblies;

18 wherein each of said fuel cell assemblies has a  
19 heat generating wafer;

20 said plurality of conduits further comprising a  
21 fuel conduit, an oxidant conduit, and an exhaust conduit;

22 and wherein each of said fuel cell assemblies  
23 further comprise a network of channels adjacent a cathode  
24 side of the wafer, thereby feeding the oxidant to every part  
25 of the cathode side of the wafer.

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2        28. The apparatus of claim 27, wherein the network of  
3 channels further comprise ridges defining the network of  
4 channels, and wherein the ridges support the wafer and  
5 provide electrical contact from the cathode side of the  
6 wafer to the fuel cell assembly.

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8        29. The apparatus of claim 28, further comprising a  
9 network of channels and ridges adjacent an anode side of the  
10 wafer, said network of channels adjacent the anode side of  
11 the wafer conducting fuel from the fuel conduit to the anode  
12 side of the wafer.

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14        30. The apparatus of claim 29, wherein the ridges  
15 adjacent the anode side of the wafer provide electrical  
16 contact from the anode side of the wafer to the fuel cell  
17 assembly.

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19        31. The apparatus of claim 30, wherein the fuel cell  
20 assemblies each further comprise a pair of interconnect  
21 plates and gaskets all having aligned holes forming the  
22 plurality of conduits.

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1        32. The apparatus of claim 31, wherein said  
2        interconnect plates and gaskets have interconnect bolts  
3        therethrough to form a stack of fuel cell assemblies.

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5        33. The apparatus of claim 32, wherein each stack has a  
6        male connector end and a female connector end, and  
7        wherein a plurality of stacks connected end to end form  
8        a stick of fuel cell assemblies.

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10       34. The apparatus of claim 33, wherein each stick  
11       further comprises an exterior casing, thereby protecting the  
12       fuel cell assemblies.

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14       35. The apparatus of claim 34 further comprising a  
15       preheater means functioning to bring the stick to an  
16       operating temperature.

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18       36. The apparatus of claim 35, wherein the stick has  
19       length selected to provide a chosen amount of heat to the  
20       underground resource layer.

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22       37. The apparatus of claim 36 further comprising spacer  
23       plates having aligned holes with the interconnect plates,  
24       said spacer plates selectively reducing a heat output of the  
25       stick.

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2       38. The apparatus of claim 36, wherein a plurality of  
3 sticks connected end to end form a string of fuel cell  
4 assemblies having a length selected to heat all or part of  
5 the underground resource layer.

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7       39. The apparatus of claim 34 further comprising a  
8 manifold connecting the string to the planetary surface,  
9 said manifold having the plurality of conduits in close  
10 proximity with each other to transfer heat from the exhaust  
11 conduit to the oxidant conduit.

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13       40. The apparatus of claim 38 further comprising an  
14 insulated current return cable attached to a bottom of the  
15 string, thereby forming a useful electric potential between  
16 a top of the string and the cable.

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18       41. A fuel cell assembly comprising: an interconnect  
19 plate having a peripheral edge;

20               said interconnect plate having a heat conductive  
21 structure;

22               a plurality of fuel cells mounted adjacent to the  
23 peripheral edge, thereby transmitting heat to the peripheral  
24 edge; and

1           a plurality of channels to the fuel cell to provide  
2 fuel and an oxidant and to transport exhaust gases.

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4       42. The apparatus of claim 41, wherein the interconnect  
5 plated further comprises a plurality of holes which form a  
6 plurality of conduits when a plurality of interconnect  
7 plates are stacked.

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9       43. A subterranean conductive heater comprising:  
10       a plurality of conduits arranged wherein at least two  
11 conduits are spaced apart and parallel to one another;  
12       a plurality of fuel cell assemblies supported  
13 between the at least two conduits which are spaced apart;  
14       and wherein the conduits communicate from a  
15 planetary surface to the plurality of fuel cells a fuel and  
16 an oxidant.

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18       44. A subterranean conductive heater comprising:  
19       a plurality of parallel conduits, at least two  
20 members of the conduits adjacent one another to exchange  
21 heat therebetween; and  
22       a plurality of fuel cell assemblies supported outbound  
23 of the plurality of parallel conduits so as to receive a  
24 fuel and an oxidant from the conduits and to transmit heat  
25 to the conduits and to transmit heat outbound.

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2        45. The apparatus of claim 44, wherein the plurality of  
3 fuel cell assemblies each further comprise a ring shape.

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